SYSTEM AND METHOD FOR MUNITION IMPACT ASSESSMENT

FIELD OF THE INVENTION

[001] The present invention relates to a unit and method for munition impact assessment. More particularly, the present invention relates to an impact assessment unit, which is added to an electronic system of a platform that monitors smart munitions.

BACKGROUND OF THE INVENTION

[002] The use of platform launched or dropped munitions in warfare is well known. The use of such munitions has provided a substantial advance in the art of warfare by facilitating the destruction of enemy targets while mitigating undesirable loss of life and/or destruction of civil and military equipment.

[003] An additional substantial advance in the art of warfare is the use of units to monitor the battlefield. Such units provide a complete centralized picture of the battlefield, and enable commanders to make decisions based on the results in the battlefield.

[004] However, conventional un-guided munitions dropped or launched by, for example, airplanes or by unmanned aircraft vehicles ("UVA"), must generally either be released with very high accuracy or in very large numbers in order to effectively destroy a desired target. Thus, it is frequently necessary to either drop such munitions from an undesirably low altitude or to fly an undesirably large number of sorties. Dropping conventional munitions from a lower than desirable altitude exposes the aircraft and crew to hazardous anti-aircraft artillery and ground-to-air missiles. For this reason, low altitude

bombing is extremely dangerous and is very rarely performed. Also, flying an undesirably large number of sorties is expensive and time consuming.

[005] In an attempt to overcome the deficiencies of conventional munitions in reliably destroying ground targets, particularly when dropped from a high altitude and far away in ground distance from the target, smart munitions have been developed. Such smart munitions utilize a guidance and flight control system to accurately maneuver the munition to the desired target. The guidance system provides control signals to the control surfaces based upon the present position of a munition and the position of the target, so that the control surfaces maneuver the munition toward the target. Such guidance systems operate according to well-known principles and typically utilize technologies such as TV guidance, laser guidance, infrared guidance, radar guidance and/or satellite (GPS) guidance.

[006] Such smart munitions can be either self guided, wherein a bomb or a missile is launched and self guides to the target, or alternatively such smart munitions can be a bomb or a missile guided or monitored by an operator, in which case the operator ensures and/or verifies that the smart munitions has reached the target. The smart munitions can be either launched or dropped from ground, air or from water.

[007] An inherent limitation to smart munitions is the inability to verify if the munition hit the target. Thus, an aircraft pilot launching smart munitions cannot verify successful impact other than by flying over the target, thus risking exposing the aircraft to anti aircraft fire.

[008] To overcome this limitation, smart munitions systems have been devised by which a likely hit coordinate signal or any other signal that informs

about a hit is transmitted from the smart munitions to an impact assessment syst m that may be located in a monitoring station just prior to detonation. Such a signal is then processed by the impact assessment system and compared to the intended targ t coordinate or to any other intended target result to yield accuracy results.

[009] An inherent limitation to the impact assessment system is the need, for example, for a radio frequency receiver and an impact assessment unit on the monitoring platform. Integration of an impact assessment unit into a monitoring platform previously required substantial modifications to the platform's electrical and avionic systems. In addition, a variety of interface software and hardware integration may also be required and therefore, numerous test flights may be required.

SUMMARY OF THE INVENTION

[0010]There is thus provided, in accordance with an embodiment of the present invention, an impact assessment unit. The impact assessment unit may include an interface connector to interface with an external slot of a platform electronic system, a resource allocation unit to negotiate access to resources associated with the platform electronic system, and a controller to regulate communication with a smart munition through a receiver associated with the platform electronics system.

[0011]Furthermore, in accordance with an embodiment of the present invention, the resource allocation unit may negotiate access to a human interface unit. In accordance with an embodiment of the present invention, the human interface unit is an audio system. In accordance with an

embodiment of the present invention, the human interface unit may be a visual display system.

[0012] Moreover, in accordance with an embodiment of the present invention, the impact assessment unit may further include a processing unit for receiving and processing information from a monitoring unit of the smart munition. In an embodiment of the present invention, the processing unit may be an external unit to the impact assessment unit. In an embodiment of the present invention, the resource allocation unit may negotiate access to the external processing unit. In an embodiment of the present invention, the resource allocation unit may negotiate access to a transmitter to transmit a signal generated by the impact assessment unit in a manner receivable by a receiving device of the smart munition. In an embodiment of the present invention, the resource allocation unit may negotiate access to a receiver to receive a signal generated by the smart munition.

[0013] Moreover, in an embodiment of the present invention, the receiver may be a radiofrequency receiver. In an embodiment of the present invention, the radiofrequency receiver may be inherent to an electronic warfare system of the monitoring unit. In an embodiment of the present invention, the radiofrequency signal may be a frequency radio signal of between 2 gigahertz and 2.6 gigahertz.

[0014] Additionally, in an embodiment of the present invention, the resource allocation unit may negotiate access to resources associated with the platform electronic system through a resource allocation controller on the platform.

[0015] In addition, in an embodiment of the present invention, the impact ass ssment unit may be placed on a monitoring unit.

[0016] Furthermore, in accordance with an embodiment of the present invention, the resource allocation unit may negotiate access to an information recordation unit to record the information received to the impact assessment unit.

[0017] Moreover, in accordance with an embodiment of the present invention, the resource allocation unit may negotiate access to a transmitter associated with the platform electronic system to transmit the information received to the impact assessment unit.

[0018] There is also provided, in an embodiment of the present invention, a method for impact assessment. The method may include connecting to an interface of a platform electronic system, negotiating access to resources associated with the platform electronic system, and regulating communication with a smart munition through a transceiver associated with the platform electronics system.

[0019] In an embodiment of the present invention, the negotiation may be to access a human interface unit. In an embodiment of the present invention, the negotiation may be to access an audio system. In an embodiment of the present invention, the negotiation may be to access a visual display system. In an embodiment of the present invention, the negotiation may be to access a transmitter to transmit a signal generated by the impact assessment unit in a manner receivable by a receiving device of the smart munition. In an embodiment of the present invention, the negotiation may be to access to a receiver to receive a signal generated by the smart munition. In an

embodiment of the present invention, the negotiation may be to access resources associated with the platform electronic system through a resource allocation controller on the platform.

[0020] Furthermore, in an embodiment of the present invention, the method for impact assessment may further include processing information for receiving and processing from an onboard guidance system/platform of the smart munition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

[0022] FIG. 1a is a cut away view of a smart munition including an impact assessment assembly according to the teachings of the present invention;

[0023] FIG. 1b is a perspective illustration of an impact assessment unit added to the existing electronic system of a platform for mounting a smart munition in accordance with some embodiments of the present invention;

[0024] FIG. 2 is a block diagram of the Impact Assessment unit of Fig. 1 operably connected to the Platform Electric System in accordance with some embodiments of the present invention;

[0025] Fig. 3 is a black box diagram depicting one embodiment of a transmitter of the impact assessment assembly of the present invention;

[0026] FIG. 4 is a diagram depicting transmission patterns over a time period of three munitions according to the present invention; and

[0027] Fig. 5 is a flow chart illustration of a method for Impact Assessment operative in accordance with some embodiments of the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0028] The present invention is of a method and system and a smart munition employing same, which may be used to determine an impact success or failure of the smart munition. Specifically, the present invention may be used to assess impact success or failure of a smart munition by providing an operator of a platform from which the smart munition was deployed, or of an

operator of a monitoring unit from which the smart munition is being monitored, with information pertaining to the position and orientation thereof with respect to a targ t, just prior to impact.

[0029] The principles and operation of a smart munition according to the present invention may be better understood with reference to the drawings and accompanying descriptions.

[0030] Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0031] As used herein, the term "munition" refers to perishable military weapons such as bombs, rockets and missiles which are typically dropped or launched on specific targets from a variety of platforms such as airplanes, UVA's, helicopters, ships, ground vehicles such as for example tanks, and personal platform launchers such as shoulder missile launchers and the like.

[0032] The phrase "smart munition" refers to any munition capable of self guiding to target and as such once it is launched or dropped from a platform it self guides to a predetermined target and to any munition guided or monitored by an operator, in which case the operator may ensure and/or verify that the munition has detonated on target. The target can be a stationary target such as a building a bunker and the like, or a moving target such as a ship, a train, an airplane or a tank.

[0033] Referring now to the drawings, FIGS. 1a-7 illustrate the smart munition according to the present invention, which is referred to hereinunder as munition 10.

[0034] Munition 10 may include a body 12, which may be cylindrical and aerodynamic, and a flight control mechanism, e.g., at least one translatable flight control surface 14 (two are shown) disposed along an outer surface of the body 12. It will be appreciated that although surfaces 14 are shown to be disposed on the outer surface of the tail section of body 12, attachment of surfaces 14 on the outer surfaces of the mid and/or forward sections of body 12 can also be realized.

[0035] Munition 10 may further include attachment elements 15 positioned on an outer surface of body 12. Attachment elements 15 may serve for attaching munition 10 to a platform 27, which can be, for example, an airplane as specifically shown in FIG. 1b.

[0036] Body 12 may house a warhead 16 which may serve to destroy a target by detonating either prior to, during or following impact of munition 10 on the target. Warhead 16 may be a hollow cylindrical shaped casing, inside of which is placed the explosive charge. The ignition fuse which is designed to be set off at the proper moment, either prior to, during or following impact on target may lie at the rear or front end of warhead 16. . Many warhead configuration and detonation mechanisms which may be utilized by warhead 16 of the present invention are known in the art, and as such no further detail to the construction and function of warhead 16 is given herein.

[0037] Body 12 may further house an onboard guidance system 18. Guidance system 18 may serve to guide munition 10 to a target by controlling control

surfaces 14. Several types of guidance systems are known in the art, which systems may utilize technologies such as, but not limited to, laser guidance, infrared guidance, radar guidance and/or sat llite (GPS) guidance. Guidance system may be housed in a front section 20 of munition 10 and may include one or more sensors 22, such as a Forward Looking Infrared (FLIR) sensors in the case of infrared guidance, and the various electronic systems which may control the sensors, analyze and interpret the signals received by the sensors, and control surfaces 14 which may determine the trajectory and the roll position of the missile.

[0038] It will be appreciated that in the case of a self propelled munition 10 such as a missile or a rocket, body 12 may further house an engine 23 such as a solid or liquid fuel rocket engine which may serve to propel munition 10 to the target.

[0039] Body 12 of munition 10 according to the present invention may further house an impact verification assembly 24. Assembly 24 may be powered by an internal power supply 21, or alternatively by a power supply contained within, for example, guidance system 18 of munition 10.

[0040] Assembly 24 may include a processing unit 26 which may be in data communication with guidance system 18 (indicated by 19). Unit 26 may serve to process information received from onboard guidance system 18, such information may include positional coordinates of munition 10 and the target (which are typically fed into the guidance system prior to deployment) and orientation of munition 10 with respect to the target. It will be appreciated that depending on the processing abilities of guidance system 18 this information may be provided either as processed data which may include a calculated

positional relationship between munition 10 and the targ t or alternatively as unproc ssed data which may includ simple coordinate data for munition 10 and target and orientation of munition 10 with respect to the horizon. In any case processing unit 26 may process the information received from guidance system 18 to yield information pertaining to an accuracy, with respect to the target, of the in-flight trajectory position of munition 10, just prior to impact. Processor 26 may generate a signal including this information and may relay this signal to a transmitter 28 forming a part of assembly 24.

[0041] Transmitter 28 may transmit this signal, via an antenna provided therewith, to a platform 27 (FIG. 1b) from which munition 10 was dropped or launched, or which may be a monitoring unit of the battle-field, such that an impact assessment of munition 10 may be determined by an operator of platform 27.

[0042] It will be appreciated that an impact assessment may depend on the extent of target destruction which may be dependent on the accuracy of munition 10, its warhead type, warhead size and penetration ability. Thus, impact success may also be achieved when near target impact occurs, providing the explosive potential of munition 10 may be such, that total or sufficient target destruction is achieved. Thus impact success may be specific to each type of munition 10 deployed. Prior to deployment a threshold for impact success may be programmed into processing unit 26 for each type of munition deployed, considering parameters such as, but not limited to, the munition warhead size, warhead type and penetration ability.

[0043] It will be appreciated that smart munitions including systems which may transmit a position and orientation of the munition to a monitoring unit exist in

the art. Such systems may transmit a signal pertaining to the position and orientation of th munition prior to impact, which signal may b correlated to a position of a target targeted by the munition, thus yielding probable impact accuracy of the munition. Since accuracy assessment in this case may be performed by a monitoring unit and not a platform from which the munition was launched or dropped, real-time analysis of impact results may not be nabled, and as such these prior art systems may be used only to verify success and not to adjust deployment of additional munitions.

[0044] These prior art systems may require the use of bulky and dedicated processing and receiving units in the monitoring unit and as such, incorporation of such units into space-limited platforms such as for example, UVA's or airplanes, is a virtual impossibility. In addition, such monitoring unit processing and receiving units may be expensive to fabricate and operate and as such incorporation into a multiplicity of platforms is not feasible economically.

[0045] To overcome the limitations of prior art systems the present invention makes use of the abundant space available within a munition body, to place the processing and transmitting functions therein such that a position and orientation of a munition with respect to a target, may be calculated on board the munition and relayed to the platform or to the monitoring unit. Performing the processing on board overcomes the space limitation imposed on the platform or on the monitoring unit, thus enabling, by utilizing a platform or a monitoring unit mounted receiver such as the electronic warfare system inherent to the platform or to the monitoring unit, to receive signals directly from the munition and as such to assess in real time the impact success or

failure of a munition. Another way to overcome limitations of prior art systems may be by sending data from the munition to the platform or to the monitoring unit, thus enabling an existing processor or processors of a platform or a monitoring unit to process the data received from the munition.

[0046] Reference is now made to Fig. 1B which is a perspective illustration of an impact assessment unit 100 added to the existing platform electronic system 200 of a platform 27 for mounting a smart munition in accordance with some embodiments of the present invention. It will be appreciated that impact assessment unit 100 may be added to an existing electronic system of a monitoring unit which may monitor the battlefield. As used herein, the term "platform electronic system" refers to the electronic system of the platform from which smart munition was deployed, or to the electronic unit of a monitoring unit from which the smart munition is being monitored.

[0047] Thus, according to an embodiment of the present invention and with reference to Fig. 2, the impact assessment unit 100 may include an interface connector 110 to interface with an external slot of the platform electronic system 200, a resource allocation unit 120 to negotiate access to resources associated with the platform electronic system 200, and a controller 130 to regulate communication with a smart munition through a receiver associated with the platform electronics system 200.

[0048] According to an embodiment of the present invention, the impact assessment unit 100 may further include a data processor unit 140 for receiving and processing information from the platform from which the smart munition was deployed, or of an operator of a monitoring unit from which the smart munition is being monitored. In an embodiment of the present

invention, the data processor unit 140 may be an external unit to the impact assessment unit 100.

[0049] Th resourc allocation unit 120 may negotiat access to resources associated with the platform electronic system 200 through a resource allocation controller 250 on the platform electronic system 200.

[0050] According to an embodiment of the present invention the signal transmitted by transmitter 28 is an electronic warfare signal which is receivable by a radiofrequency receiver 210 of the platform electronic system 200. The receiver 210 may be inherent to an electronic warfare system of the platform electronic system 200. The electronic warfare may be an example of a communication unit 220 which may exist on the platform electronic system 200.

[0051] According to another embodiment of the present invention the electronic warfare signal transmitted by transmitter 28 is of a frequency selected between 2 gigahertz and 2.6 gigahertz with a bandwidth of 5-10 MHz.

[0052] As is specifically shown in FIG. 3, to enable generation and transmission of an electronic warfare signal of this frequency range and bandwidth transmitter 28 may include a control and interface unit 30 which may serve to receive the signal (indicated by 29) from processing unit 26. Transmitter 28 may also include a modulator 32 which may serve to convert a voice information signal or in addition digital data, such as image data, signal into a radiofrequency signal (indicated by 31) and to relay the radiofrequency signal to a power amplifier 34 such that the electronic warfare signal may be amplified thereby prior to transmission via the antenna 36.

[0053] Th electronic warfare signal received by a receiver on board platform 27 or on board the monitoring unit may then be translated thereby to information indicating ither success or failure of impact, of munition 10.

[0054] Thus, the transmission of the electronic warfare signal may be effected during the last minute of flight of munition 10, preferably during the last few seconds of flight. Initiation of transmission may be determined according to the proximity of munition 10 to the target which may be determined according to information from guidance system 18. It will be appreciated that the electronic warfare signal may be transmitted from munition 10 from the moment of release until impact in which case an operator of platform 27 or of the monitoring unit may choose to ignore the signal until a minute or so prior to impact.

[0055] It will be appreciated that the ability to forecast impact success may be inversely proportional to the distance between munition 10 and the target. That is to say, the closer munition 10 is to target (i.e., the less time remaining to impact) the more accurate the impact success or failure forecast is. It will further be appreciated that if this forecast is effected on the basis of information transmitted from munition 10 a few seconds prior to impact such a forecast may be substantially 100% reliable.

[0056] Thus, by utilizing electronic warfare communication no modifications or addition of hardware to the platform or to the monitoring unit are necessary, greatly simplifying deployment of munition 10 of the present invention. In addition, since the electronic warfare system inherent to the platform electronic system 200 may be utilized as a receiver, minimal operator training and handling is required.

[0057] According to an embodiment of the present invention, the resource allocation unit 120 may negotiate access to a human interface unit 230 on the platform electronic system. The human interface unit may be for example an audio system or a visual display system.

[0058] According to another embodiment of the present invention the lectronic warfare signal may translate into audio information by the communication unit 220 of the platform electronic system 200. Such audio information may include uttered words (voice) or any other form of audio information which may be indicative of impact success or failure. For example, this information may include either a "hit" or a "miss" message, which may indicate to the operator of platform 27 or of the monitoring unit an impact success or failure. It will be appreciated that through experimentation it will be possible to determine which uttered words or combinations of words and which voice frequencies and intonations may be best suited for the relaying the munition impact success or failure message to an operator of platform 27 or of the monitoring unit. It will be appreciated in this respect that voices of male, female and child are readily discernible and the content thereof identifiable even if simultaneously transmitted through a multiple users communication system.

[0059] As specifically shown in FIG. 2, the platform electronic system 200 may include a communication unit 220, a human interface unit 230, a processor unit 240, and a resource allocation unit 250. As already mentioned above, communication unit 220 may be for example a warfare electronic unit. In addition, the human interface unit may be for example an audio system or a visual display system. The incoming electronic warfare signal may be

converted into audio information, preferably voice, or to visual display, which may be receivable and comprehended by an operator of platform 27 or of the monitoring unit. In addition, the information, whether it is an audio information, or a digital data information, such as image data, can be recorded for later analysis. Digital data may be transmitted, for example, by QPSK modulation.

[0060] According to another embodiment of the present invention when the impact success of more than one munition 10 is to be co-assessed, the signal generated and transmitted by impact verification assembly 24 of each munition 10 may also include information uniquely identifying each munition 10.

[0061] It will be appreciated that since in, for example, aerial bombing runs more than one munition 10 may be deployed either by a single or a plurality of airplanes targeting one or more targets, individually tracking and assessing impact success of each munition 10 has to be enabled.

[0062] In such cases, each munition 10 may be preprogrammed to transmit a signal including a unique identifier in addition to the information pertaining to impact success or failure. The unique identifier may be for example audio (e.g., voice) information including, for example, a single word selected from the words representing the international alphabet of radio communication (Alpha, Bravo Charlie etc.). Thus munition 10 may transmit a signal such as Alpha-"hit" which may identify the specific munition 10 and the impact success or failure thereof.

[0063] In order to discern between the signal transmitted from a plurality of munitions 10 co-deployed the signal of each specific munition 10 may be transmitted in a random manner over a time period such that each signal is

individually received at least once over this time period by platform electronic system 200.

[0064] For xample, when thre munitions 10 are co-launched from an airplane or airplanes a suitable transmission time window, a number of time windows in a time period and a number of transmissions in each time window, may be determined such that signals from munitions 10 are individually received by platform electronic system 200 at least once during this time p riod.

[0065] Thus, for three munitions, the probability of successful transmissions non-overlapping) over a time period may be represented as follows: $P=nx(n-1)^2/n^3$, wherein n=the number of time windows over a time period, n.sup.3=the number of possible co-transmission for three munitions 10 in a time window, and $nx(n-1)^2$ the number of possible non-overlapping transmissions in a single time window.

[0066] Thus, 1-P is the probability of an unsuccessful transmission (i.e., if two transmissions overlap and thus may not be individually discerned) if Z is the number of time windows necessary and if X is a successful transmission then $X=1-(1-P)^Z$. Extracting Z yields the following: Z=log (1-x)/log (1-P).

[0067] Assuming a one second transmission time and applying the above calculations for four munitions 10, yields an optimal time period of 35 seconds which includes 5 time windows of 7 seconds each, for obtaining probability of 95% of non-overlap. As specifically shown in FIG. 4, if all four munitions (represented by bomb 1, 2, 3 and 4) are transmitting (each transmission, i.e., transmit frame, is represented by a single rectangle) randomly over this time period (time windows 1-4), each signal may be individually received by the

receiver of platform 27 or of the monitoring unit at least one time during this time period (time window 3). It will be appreciated that by increasing the number of time windows or the number of optional transmissions per window one may increase the non-overlap probability.

[0068] Thus the present invention may provides a smart munition including an impact verification assembly which may enable the operator of a platform from which the munition was dropped or launched, or the operator of a monitoring unit which may monitor the battlefield, to determine, in real time, an impact success or failure of the munition.

[0069] The smart munition of the present invention may readily be incorporated and deployed by existing platforms or monitoring units without necessitating additional platform or monitoring unit mounted hardware or extensive operator training. In addition the smart munition of the present invention may enable the co-assessment of impact success of a plurality of munitions which may be targeted against one or more targets.

[0070] It will be appreciated that assembly 24 of the present invention may be retrofitted into any existing smart munition, providing suitable coupling conduits may be provided such that communication with a guidance system can be established.

[0071] According to an embodiment of the present invention, a method for impact assessment is presented. Reference is now made to Fig. 5 which is a flow chart illustration of the method for Impact Assessment operative in accordance with some embodiments of the present invention. The method may include connecting to an interface of a platform electronic system (step 1000), negotiating access to resources associated with the platform electronic

system (step 2000), and regulating communication with a smart munition through a transceiver associated with the platform electronics system (step 3000).

[0072] In an embodiment of the present invention, the negotiation (step 2000) may be to access a human interface unit. The negotiation may be for example to access an audio system or to access a visual display system. In an embodiment of the present invention, the negotiation may be to access a transmitter to transmit a signal generated by the impact assessment unit in a manner receivable by a receiving device of the smart munition. The negotiation may be to access to a receiver to receive a signal generated by the smart munition. In an embodiment of the present invention, the negotiation may be to access resources associated with the platform electronic system through a resource allocation controller on the platform.

[0073] Furthermore, in an embodiment of the present invention, the method for impact assessment may further include processing information for receiving and processing from an onboard guidance system/platform of the smart munition (step 4000). The method for impact assessment may further include presentation or recordation of the information (step 5000), whether it is an audio information, or a digital data information, such as image data.

[0074] Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

[0075] It will be appreciated by p rsons skilled in the art that the present invention is not limited by what has been particularly shown and described herein above. Rather the scop of the invention is defined by the claims which follow: